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**Measurement of Local Gain and Electron Density in an
Yttrium X-ray Laser Amplifier***

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There has long been a discrepancy between predicted gains from collisionally-pumped, neon-like x-ray lasers and the signals actually observed. For the yttrium laser under ideal conditions (electron densities of about 10^{21} cm^{-3} and temperatures around 1 keV), kinetics codes predict the gain of the two lasing lines to be about 25 cm^{-1} . Experiments have typically measured gains of around 5 cm^{-1} . Proposed reasons for the large difference have centered on refraction of the laser in the ($\sim 3\text{-cm-long}$) line plasma. To simultaneously measure electron density and *local* gain under lasing conditions but with minimal refraction, we produced a 1-mm-long yttrium line plasma which was employed as an amplifier for a separately-produced, primary yttrium x-ray laser. The amplifier was viewed end-on with $\sim 2 \text{ }\mu\text{m}$ resolution so that local gain was measured. Multilayer optics produced a Mach-Zehnder interferometer with the primary beam so that, simultaneous with the gain measurement, the electron density was observed with the same resolution. Measured gains in the amplifier were found to be between 20 and 35 cm^{-1} , similar to predictions and indicating that refraction is indeed the major cause of signal loss in long line focus lasers. Images showed that high gain was produced in spots with dimensions of $\sim 10 \text{ }\mu\text{m}$. We believe that this is caused by intensity variations in the optical drive laser. Interferometry indicated that density variations were not a significant factor so that temperature variations were responsible for the localized gain regions. The fact that much of the laser gain is produced in small regions may place a limitation on the coherence available from plasma-produced lasers.

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